with the gases of external space. Similarly, little progress has been made toward a determination since the time of Laplace of the total mass of the atmosphere. If the earth did not rotate and if the distribution of the atmosphere were adiabatic, its height would be limited to about 17 miles and the total mass would be a little more than one-millionth part of the entire mass of the earth. But the earth rotates and while the distribution near the surface of the oceans is approximately adiabatic it is probable that this law does not hold at any great height. Hence, if we suppose the mass distribution to be such as conceived by Laplace, the total mass must be much larger than the lower limit just assigned. Here, then, are two capital problems available for research by aid of the more recently acquired resources of knowledge concerning the constitution of gases.

Recent researches, and especially those of Bjerknes in his Dynamic Meteorology, have gone far toward a rational treatment of the kinetic properties of the atmosphere, and we may confidently entertain the hope that rapid progress will be practicable in the near future.

NOTE ON A MIRAGE AT SEA.

[Dated July 3, 1919.]

Ship's position [U. S. S. *Radnor*] 40° 26′ N., longitude 64° W., apparent time of ship, 4 p. m. Light easterly winds, smooth sea, barometer 29.94 inches; my personal barometer, 30.00 inches; air, wet bulb, 59°; air, dry bulb, 63°; temperature of sea at surface, 53°; overcast with cumulus clouds. Strong mirages noted all around. Four other ships were in sight at the time. These vessels appeared at times to be steaming along at the top of a hugh wall of ice; at other times the bodies of the ship seemed to rise out of the water at least twice their height. Horizon had all the appearance of a long, rugged coast line.—*M. S. Harloe, Lieut. Commander, U. S. N. R. F.*

THE SUN'S INFLUENCE ON THE DIURNAL VARIATION OF THE ATMOSPHERIC POTENTIAL-GRADIENT.[1]

By W. F. G. SWANN.

Professor of Physics, University of Minnesota.

[Dated Minneapolis, Minn., July 10, 1919.]

SYNOPSIS.—The paper presents a view as to a possible origin of part of the diurnal variation of the atmospheric potential-gradient.

Various phenomena in cosmical physics lend support to the view that the upper atmosphere is so highly conducting as compared with the air near the earth's surface that, for electrostatic considerations, it may be looked upon as perfectly conducting. Thus, for example, we may look upon all points on a sphere in the upper atmosphere, concentric with the earth, as being at the same potential.

If the conductivity of the atmosphere depended only upon the altitude, and were independent of the position on the earth's surface with respect to the sun, the surfaces of equal conductivity would be spheres concentric with the earth, and the conduction current-density and potential-gradient would be independent of the position on the earth's surface. If the sun emits an ionizing radiation, however, we may expect the surfaces of equal conductivity to be dented inward toward the earth when the sun is at the zenith. Thus, the total resistance of a column of air of unit cross section, extending from the earth's surface to a given altitude in the upper atmosphere, would be least when the sun was at the zenith. It would result that the atmospheric conduction current-density would be greatest when the sun was at the zenith; and, if the conductivity of the air at the surface of the earth were the same at all places, we should have a higher potential-gradient on the sunlit portions of the earth than on those remote from the sun.

The ideas contained in the above outline are illustrated in the second portion of the paper by an example which is worked out mathematically. The bearing of these considerations upon the effect of an eclipse on the potential-gradient is also discussed.

Various phenomena in cosmical physics lend support to the view that the upper atmosphere is highly conducting as compared with the air near the earth. Thus, for example, Schuster has developed a theory of the diurnal variations of terrestrial magnetism which invokes, among its requirements, a conductivity about 3×10^{11} times as great as that at the earth's surface. Such a value appears by no means unreasonable when viewed in the light of our beliefs as to the processes at work in the upper atmosphere. The sun's ultra-violet light alone, although insufficient to account for a conductivity of the order of magnitude required by Schuster's theory is able, as the writer has shown,[2] to account for a magnitude one thousandth of this amount, i. e., a conductivity so high that a column of air extending one-fourth of the way around the earth in the upper atmosphere would offer no more resistance than would a column of surface air of equal cross section, but only 3 cms. long.

If the upper atmosphere has a conductivity approximating even to that which the ultra-violet light is capable of accounting for in the sunlit regions, it may, for most electrostatic purposes, be considered as a perfect conductor.

If two concentric spheres be maintained at a difference of potential, the field at the surface of the inner sphere will, from symmetry, be the same at all points of the surface. If a dent be made in the outer sphere, the distance between the spheres at this point will be decreased, and, since each sphere is at the same potential all over, the field at the surface of the inner sphere, under the dent, will be stronger than that elsewhere. Or if, instead of making a dent in the outer sphere we fill the space between the spheres with a medium which is slightly conducting, and in which the conductivity is the same at all points except that at one place it increases from its normal value as we go from the inner to the outer sphere, then the current density will be greater at this place than elsewhere, and the potential-gradient at the surface of the inner sphere will be greater here than elsewhere.

The above crude illustration suggests that if the upper atmosphere is in a highly conducting state, but the conductivity mounts more rapidly with altitude on the sunlit side than on the side more remote from the sun, the potential-gradient should be higher in the former case than in the latter. Here, then, would be an influence playing a part in the determination of the diurnal variation of the potential-gradient, and of such a type as to predict a maximum of the potential-gradient by day and a minimum by night.

On a view of this kind the air-earth conduction current-density at the earth's surface should go through a diurnal variation of the same kind as the potential-gradient, unless the surface conductivity also varies throughout the day. Actual observations bring out the fact that, as a general rule, the conductivity at the earth's surface varies in the opposite sense to the potential-gradient, and in such a way as to maintain the product of the two (the air-earth current-density) more nearly independent of the time of day than either of its constituent factors. The general nature of the phenomena is such as to suggest that the quantity fundamentally determined is the air-

[1] Read before the May meeting of the Mathematical Association of America.
[2] Terr. Mag., v. 21, pp. 1-8, 1916.